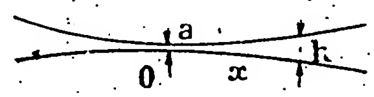
No. 20,406/29.

Fig. 1.



Space packing

Fig. 2.

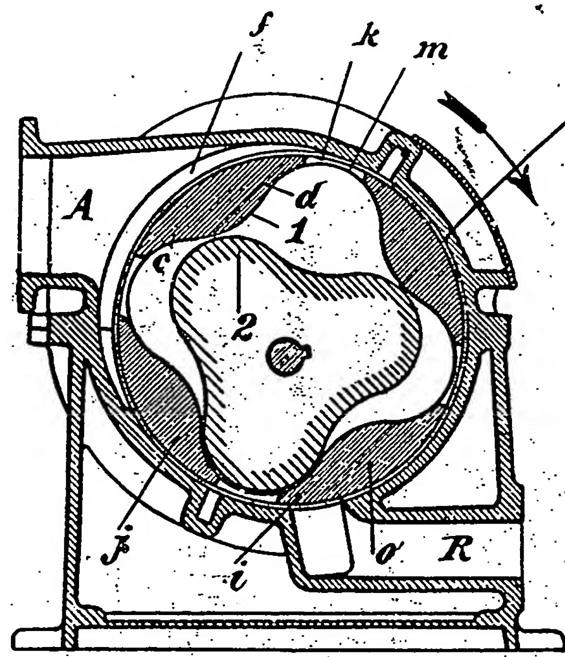
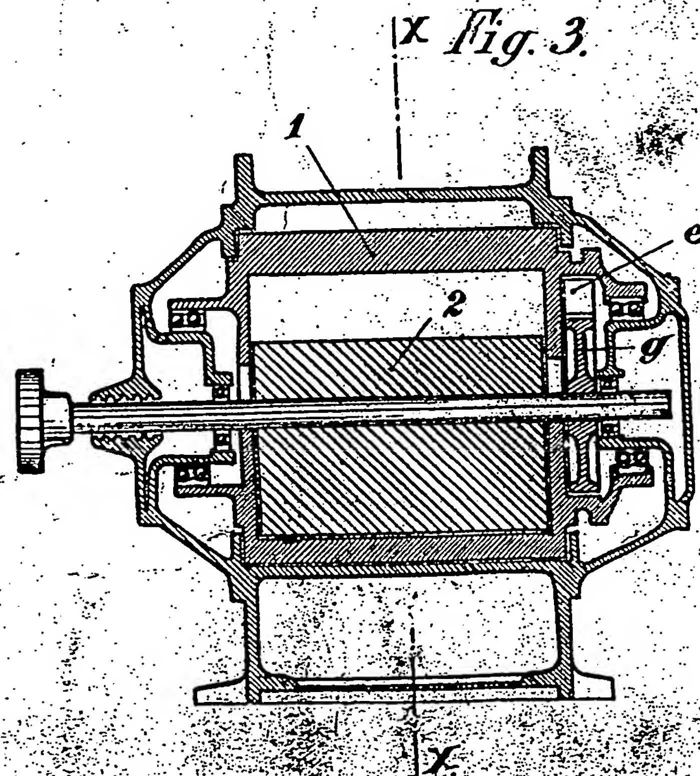


Fig. 3.



timing gears

418-166

Department of Patents. Patents Act 1903-1921. Commonwealth of Australia.

No. 20,406/29.

APPLICATION DATED

31st May, 1929.

Under International or Intercolonial Arrangements.
(France, 27th July, 1928.)

Applicant ... ... SOCIÉTÉ ANONYME POUR L'EXPLOITATION DES PROCÉDÉS MAURICE LEBLANC-VICKERS.

Application and Complete Specification ... Accepted 4th December, 1929.

Acceptance Advertised (*Sec.* 50) ... ... 17th December, 1929.

Classes 29.4; 67.6; 68.8; 69.8.

Drawing attached.

COMPLETE SPECIFICATION.

"Compressors with two rotors, more particularly applicable to water-vapour refrigerating machines."

We, SOCIÉTÉ ANONYME POUR L'EXPLOITATION DES PROCÉDÉS MAURICE LEBLANC-VICKERS, a Body Corporate organised according to the laws of France, of 12 Rue Portalis, Paris, France, Manufacturers, hereby declare this invention and the manner in which it is to be performed to be fully described and ascertained in and by the following statement:—

The present invention relates to rotary volumetric compressors comprising two rotors located eccentrically with respect to each other and making mutual contact by two conjugated surfaces, in a way similar to toothed wheels, wherein the work of compressing the fluid is effected by the engagement of the projections on one of the rotors in the corresponding hollows of the other, in a manner similar to that of an internally toothed gear.

More particularly, and by way of example, there will be described the application of the invention to compressors the two rotors of which have conjugated axially symmetrical surfaces of the order n and $n+l$ respectively.

The subject matter of the invention is improvements in compressors of the aforesaid types for the purpose of adapting them for use, especially with refrigerating machines for the compression of water-vapour at low pressure and especially with those machines wherein a transmission by toothed gear or the like is provided for driving them.

The adoption, in many respects so advantageous, of water-vapour as refrigerating fluid, encounters many difficulties arising mainly from the large specific volume of this vapour at low pressures. In fact, whilst turbo-compressors of the usual type would in principle be particularly well adapted for the large volumetric outputs which the use of water-vapour necessitates, yet the predominance in the gases at very low pressure of the forces of viscosity over all others, which are dependent upon the pressure or the mass such as forces of inertia, renders

1 2

their working difficult, or their efficiency impaired in the present case. It is thus necessary to have recourse to so-called volumetric apparatus, either reciprocating or rotary, in which compression is effected by restriction within a closed chamber of variable capacity of a fixed quantity of fluid. Finally the necessity of keeping within reasonable dimensions whilst using high speeds, puts out of the question both machines with pistons as well as all such rotary ones as comprise members, such as sliding vanes, in reciprocal motion, and only allows of definitely retaining solely machines which are truly rotary, constituted by solid rotors rotating about their axis of symmetry and balanced by the fact.

It has already been proposed to construct such a machine of two rotors eccentric with respect to each other, having respectively the one n teeth and the other $n+l$ teeth arranged symmetrically around their axes, the surfaces of which are conjugated like those of toothed gearing so as to restrict between their points of contact a series of chambers, the capacity of which changes periodically when the two rotors rotate together, each about its own axis, at speeds proportional respectively to $n+l$ and n.

In the known constructions the prevention of leakage necessitates either the use of movable packings similar to segments, carried by one of the rotors and rubbing against the other, or a very close contact between the two rotors, which, owing to the friction produced, prevents recourse being had to the high speeds required for compressing a fluid of low density.

It is in order to avoid this drawback that the applicant has thought of the solution, paradoxical as it may seem at first sight, which consists in doing away with all friction between the rotors by providing voluntarily and in the manufacture between said rotors a systematic clearance or gap, which however does not involve a sensible leakage. The fluid in question possesses in fact, under the conditions of low temperature involved, a great kinematic viscosity (quotient of the absolute viscosity by the specific mass) and the existence of the clearance in the case of such a fluid does not occasion any harmful leaks, provided always that this clearance satisfies certain conditions.

The flow of a viscid fluid in a narrow channel, which will be designated clearance depends, not only, as in the labyrinth packings of turbines, on the width of this clearance and on the number of successive contractions which it offers to the flow, but also in large measure on the shape and extent of this clearance in the direction of the current.

If one considers for example the case of the leak from one compression chamber to the adjacent one in which there exists a lower pressure, through the clearance which is symmetrically arranged according to the invention in the region of the point of contact of the two surfaces (Fig. 1); then in the neighbourhood of this point of contact, if the two surfaces have a continuous curvature, the clearance h may be expressed as a first approximation by the equation

$$h = a + bx^2$$

Where a is the minimum clearance or gap between the two rotors, x the arc reckoned from the corresponding point and $2b$ a constant equal to the algebraical difference of curvature of the two surfaces in the neighbourhood of their point of contact. In these conditions, calculation shows that the forces of inertia upon which chiefly depends the velocity attained in the clearance in the ordinary case of the labyrinths of turbines are on the contrary negligible in the present case in comparison with the forces of viscosity.

It is then possible to show that the total leakage output per unit of length of the clearance along the generatrix depends not only on the minimum clearance a but also on the curvature b, which characterises the respective shape of the two rotors in the neighborhood of their point of contact and which is the smaller as the corresponding surfaces approach the more nearly to each other in this region.

The clearance a which represents the minimum distance between the two rotors at the point in which they are nearest together, cannot be reduced below a certain limit for reasons of mechanical safety, this clearance should in fact be always fairly large so that, notwithstanding the thermal expansions or mechanical elongations which the members may undergo when the machine is working, there shall never be any contacts; on the other hand it is possible by a suitable choice of the surface to reduce leakage by acting upon b.

This is the point to which the applicant's claims are directed; with respect to the nature of the conjugated surfaces used for the peripheries of the two rotors in the compressor according to the invention.

In the known constructions of this type of compressor, in order to prevent leakage it is necessary to use either movable packings of the nature of segments carried by one of the rotors and held in contact with the periphery of the other, or a very close contact of the invariable conjugated surfaces of the two rotors. Moreover, these conjugated surfaces are usually composite, that is to say, comprise successive portions shaped as festoons, epicycloids and hypocycloids joined at their points of retrogression.

In both cases the omission of the clearance between the two rotors prevents the use of the high speeds required in the application to rarefied fluids owing to the excessive friction, which is caused by inevitable deformations and dilatations.

An essential characteristic of the present invention is to be found in the fact that a certain clearance is systematically provided by design as in turbines, both between the rotating members as well as between the rotating members and the stationary members and generally speaking between all members in relative motion without there being risk of leakage between two adjacent chambers.

It is indeed the fluid to be compressed which, owing to its viscosity, itself ensures this absence of leak and that to the exclusion of all segments and generally speaking to the exclusion of all metallic or other members, which according to the usual practice would be carried on one rotor and would rub against the other. All friction between any parts whatever of the two rotors, or between solid members attached to one or other of them is thus systematically avoided and at the periphery of these rotors there exists only the friction between the surfaces of these solids and the rarefied fluid which is to be compressed. Thus no lubricant is necessary between the surfaces in relative motion. It is the viscid fluid itself which here also fulfils this purpose.

Experience shows that in the conditions contemplated by the present invention in its application to a fluid with predominant viscosity, the existence of the aforesaid systematic clearance, so long as it remains within certain limits, does not give rise to sensible leaks of the fluid between the chamber wherein it is compressed and the adjacent chambers in which the pressure is less. The use in the machines above mentioned of this apparently surprising phenomenon constitutes one of the essential features of the present invention.

In order to reduce to a minimum the leaks in the clearance in the compressor according to the invention, the conjugated surfaces of the two rotors have nowhere any point of retrogression; on the contrary these surfaces are chosen in such manner that the radius of curvature of them is everywhere greater than a certain minimum of the order of two to three times the distance between the axes of the rotors themselves, so that the leak for a given clearance remains as small as possible, whatever may be the position of the point of contact along the surfaces.

For example, in the preferred construction shown in Figure 2, the surface of the inner rotor is the curve parallel to the envelope of only a portion l of the surface of the outer rotor, constituted by a circular arc c d of fairly large radius and has nowhere any point of retrogression like those of surfaces constituted by juxtaposition of epicycloids and hypocycloids, that is to say, of distinct analytical curves.

This continuity of surfaces in the first place results in the advantage of easier and surer machining by obviating the difficulty of exactly connecting at their points of retrogression two different curves, which have to be machined successively. It ensures, moreover as already stated a greater freedom from leakage the same clearance in all the successive positions of the point of clearance or of minimum clearance along the surfaces, by everywhere keeping down as low as possible the difference between the respective curvatures of the two opposed surfaces.

Because of the clearance, which must be maintained by one of the rotors 1 and 2 with respect to the other, the mutual drive cannot be secured by the conjugated surfaces, but must be produced in the known way by means of a gear the toothed wheels e and g of which, shown in the longitudinal section Figure 3, should have the same pitch-circle as the surfaces themselves.

Besides the leaks above-mentioned from one compression chamber to the adjacent one through the points of minimum clearance between the surfaces of the two rotors, a compressor of the type according to the invention is liable to other leaks; some occur between the two rotors along their side plates and put the compression chambers into communication with each other or with the suction inlet of the compressor; others occur

between the outer rotor and the casing or stator, which encloses the moving members, and they put the delivery of the compressor into direct communication with the suction inlet.

Owing to the long development of these clearances between the suction and delivery sides of the compressor, in which there exist different pressures, the pressure slope is very slight and only sets up generally but a very slight leakage current from the delivery to the suction. On the contrary the velocity of the fluid through the joint is almost exclusively regulated by the relative movement of the two facing walls, which constitute the clearance and to which it adheres perfectly owing to its viscosity. In consequence of the linear distribution from one wall to the other of the peripheral velocity resulting for the fluid, the volume transported with respect to the stationary wall owing to the motion of the movable wall corresponds to a mean velocity, which is half the velocity of the moving wall.

In a comparatively short portion of the periphery of the compressor **i j** extending from the delivery outlet R to the suction inlet A, this sweeping of the fluid taking place in the direction of the motion of the rotors as shown by the arrow in Figure 1, is harmful, since it constitutes a return from the delivery towards the suction and consequently a leakage. It is thus desirable to diminish the clearance in this portion so far as may be done compatibly with sure working and the keeping within an admissible amount of the loss due to friction or viscosity which is in inverse proportion to the amount of clearance.

On the other hand in the much more extended portion **k o** of the periphery extending from the suction A to the delivery R the fluid thus transported by the motion of the rotor is added to the useful output although with a lower efficiency, in a way similar to that in the so-called molecular pumps of Gaede or Holweck. In this portion therefore the clearance may be increased with advantage to a considerable extent without risk of a harmful reflux owing to the back pressure.

In accordance with this consideration the compressor according to the invention has a different clearance at the portion **i j** and **k o** obtained for example by an eccentric boring of the portion **k o** of the casing.

The maintenance even at high speeds of a suitable amount of clearance, never nil but not too great, requires that the changes in shape of the surfaces of the rotors owing to centrifugal force should be as small as possible, which may be obtained by means of various suitable methods of construction.

Having now fully described and ascertained our said invention and the manner in which it is to be performed, we declare that what we claim is:—

1. Volumetric compressor particularly adapted for use with a refrigerating machine working with rarefied refrigerating fluid, comprising rotors eccentrically disposed with respect to each other, and having conjugate teeth, characterized by that, for the purpose of avoiding friction of the solid members against each other, and of permitting a high speed of rotation, the said compressor is disposed in such way that a systematic clearance is maintained between the two rotors in all their relative positions, and, if necessary, between the exterior periphery of the external rotor and the interior surface of the casing, between the side plates of the rotors and the side plates of the casing and generally between the members of the compressor having relative motion, said clearance being however maintained within such limits and the profiles of the rotors being calculated in such manner that any leakage is prevented by the mere viscosity of the rarefied refrigerating fluid.

2. Compressor, as claimed in Claim 1, characterized by that the profiles of the two rotors are such that the radii of curvature at the points of maximum closeness of these two profiles not only never annul each other (that is to say that these profiles have no points of inflection) but are everywhere greater than a certain minimum of the order of twice or thrice the distance between the axes of the rotors themselves, so that the leakage of fluid between the two rotors remains as small as possible notwithstanding the presence of the systematic clearance.

3. Compressor, as claimed in Claims 1 and 2 characterized by that one of the conjugate profiles is entirely constituted by the single envelope of a portion of the surface of the other.

4. Compressor, as claimed in Claims 1 to 3, characterized by that the portion of surface enveloped of one of the rotors is constituted by circular arcs of large radius, of

which the conjugate surface of the other rotor is the envelope.

5. Compressor as claimed in Claims 1 to 4, characterized by that the peripheral gap between the exterior rotor and the casing is not uniform, but on the contrary narrower or wider at different regions of the periphery according as the corresponding output produced detracts from or aids the volumetric efficiency of the whole.

6. Compressor as claimed in Claims 1 to 5, characterized by that the two rotors have conjugate surfaces of axial symmetry of the order n and $n+l$ respectively.

Dated this 31st day of May, 1929.

SOCIÉTÉ ANONYME POUR L'EXPLOITATION DES PROCÉDÉS MAURICE LEBLANC-VICKERS,
By their Patent Attorney,
CLEM. A. HACK.

Witness—H. McCawley.

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